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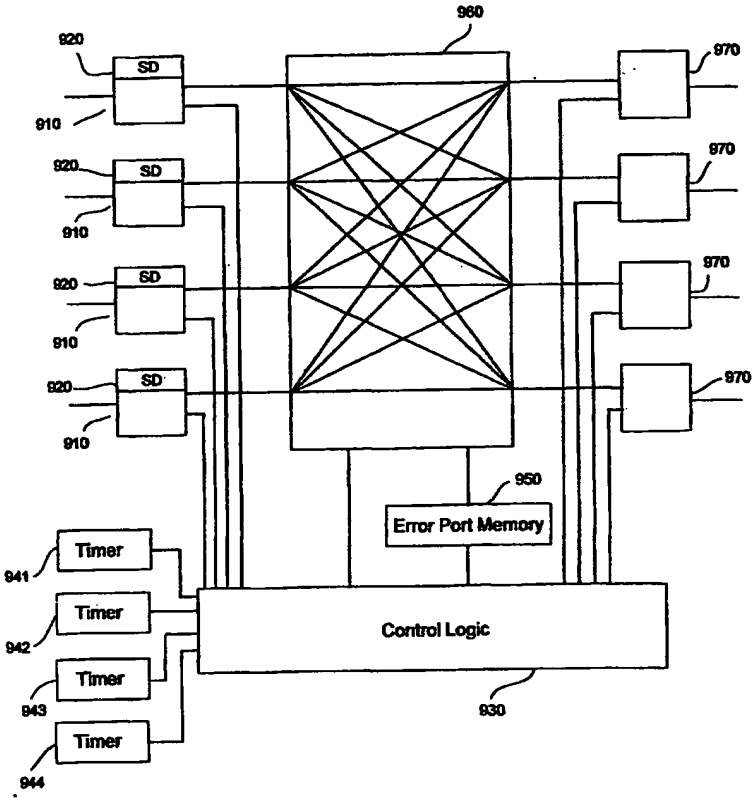
*[Continued on next page]*

(54) Title: ERROR PROPAGATION AND SIGNAL PATH PROTECTION IN OPTICAL NETWORK




(57) Abstract: A method and a device in a cross-connector node in an optical network for error propagation and signal path protection including supervision of incoming signal on input port, switching off of output port at loss of signal, alternatively switching so that output port is connected to signal source being part of protected path, and restart respective reconnection at detection of recurred signal.



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# ERROR PROPAGATION AND SIGNAL PATH PROTECTION IN OPTICAL NETWORK

## TECHNICAL FIELD

The present invention relates to error propagation and signal path protection in optical communication networks.

## PRIOR ART

At a fiber break or at error in a laser in a static optical network, the error will propagate through the network by itself. Transponders propagate/transmit the error by switching off themselves when they have no incoming light. In a completely optical network the light is not regenerated; consequently the error there will propagate in a natural way. Thus, the loss of signal will be detectable further on along the transmission path. If, on the other hand, there are electro-optical cross-connectors in the network, more logic is required to make the error propagate. The laser in a transceiver is not switched off automatically. Besides, the signal will have its input into a cross-connector by one of several Rx-ports (reception ports) and its output by one or more Tx-ports (transmission ports).

The aim of the present invention is to provide a method to achieve that a signal error, which has been detected in the optical network, propagates in the transmission direction, to at that make it possible to be detected by subsequent nodes in the network and by that make switching off/disconnection of related transmission ports possible, alternatively achieve that related cross-connectors perform so called protection switching.

## SUMMARY OF THE INVENTION

The invention relates to a method and an arrangement in a cross-connection node in an optical network including supervision of incoming signal on input port, switching

off/disconnection of output port at loss of signal, alternatively switching so that output port is interconnected with signal source being part of protection path, and restart respective re-switching at detection of recurred signal.

The invention is defined in the patent claims. Preferred embodiments are defined in the subclaims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described in detail below with reference to the figures below, of which:

Figure 1 shows a cross-connector node with control logic;

Figure 2 shows signal propagation via a primary signal path in an optical network with a number of letter-marked nodes;

Figure 3 shows the network in Figure 1 inclusive a protection signal path; and

Figure 4-8 show error propagation and events if an error occurs.

Figure 4:

A = An error occurs, i.e. the laser fails in node c, or the fiber between c and d is broken/cut. Signal detection at input port of node d detects loss of signal.

Figure 5:

B = Propagate the error, i.e. find laser to which input port is connected and switch off.

Figure 6:

C = Propagate the error, i.e. find laser to which input port is connected and switch off.

Figure 7:

D = Propagate the error, i.e. find laser to which input port is connected and switch off.

Figure 8:

E = This is the last node in the path. Perform cross-connection to protection path. Don't switch off the laser!

Figure 9 shows a cross-connector node and control logic according to one embodiment of the invention;

Figures 10a-d and 11 show a flow chart for a method according to one preferred embodiment of the invention.

Figure 10a:

A = Input signal lost/lacking ?

B = Initiate timer

C = Store input port ID

D = Store output port ID

E = Timer period expired ?

F = Input signal still lost/lacking ?

G = Output port is end port in protected path

H = Connect input port from protected path to output port

I = output port is part of protected path ?

J = switch off output port (i.e. the laser)

Figure 10b:

K = Output port is end port in primary path ?

L = Output port is part of primary path ?

M = Switch off output port (i.e. the laser)

Figure 10c:

N = Signal back ?

O = Initiate timer

P = Timer period expired ?

Q = Signal still on/in existence ?

R = Output port is end port in protected path ?

S = Connect input port from protected path to output port

T = Output port is part of protected path ?

U = Switch on output port (i.e. the laser)

Figure 10d:

V = Output port is end port in primary path ?

W = Output port is part of primary path ?

X = Switch on output port

Figure 11:

A = Start. Input Port is the input port which is connected to this Output Port. Prot. Port is defined if this is end port in primary path.

B = Input signal not existing/lacking from input port ?

C = Initiate timer

D = Timer period expired ?

E = Input signal not existing/lacking from input port ?

F = This output port is end port in primary path

G = Connect input port from protection path to output port (connect Prot. Port to Output Port)

H = This output port is part of primary path ?

I = Switch off laser of Output Port

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention relates to error detection and signal error propagation in networks with opto-electrical cross-connectors where one wants to have the possibility to propagate loss of signal and possibly perform 1+1-protection. The invention includes a method to detect loss of signal at inputs to cross-connector nodes, transmission of loss of signal to outputs of cross-connector nodes, and decision method and control method for performing of protection switching for protected signal paths.

One preferred embodiment is described here with reference to Figure 1. Figure 1 shows a cross-connector node 101 with a control logic 120 which is connected to and controls a number of input ports 110 and a number of output ports 140. Between the input ports 110 and the output ports 140, a switch matrix 130 is arranged which also is connected to the control logic and which makes possible that just any input port can be connected to just any output port, controlled from the control logic 120. In the case that a signal on an input port 110 disappears, this

dropout is detected and the control logic 120 in the cross-connector node 101 checks which output port/ports 140 that are interconnected with said input port 110 in the switch matrix 130, and switches off these output ports 140, or alternatively performs protection switching.

The function is shown in the example in Figures 2-8.

Figure 2 shows a primary signal path 210 which extends over the nodes a-c-d-j-l-m. Figure 3 shows a redundant signal path 310 which extends over the nodes a-b-f-g-i-n-m; the first node a) transmits the signal both paths, that is, both to node b) and node c). The fact that a redundant signal path has been established results in that the primary path is called protected path.

Figure 4 shows what will happen if an error occurs on the path between node c) and node d). The error can, for instance, consist of that the transmitter laser in node c) fails, or that the optical fiber between node c) and node d) is cut/broken. A signal detection unit at input port in question at node d) detects the occurred loss of signal.

Figure 5 shows how one embodiment of the invention by its influence in/effect on node d) propagates the error to the signal path between node d) and node j), that is, the transmitting laser which is connected to the input port which receives signal from node c) has been switched off.

Figure 6 shows how one embodiment of the invention by its influence in/effect on node j) propagates the error to the signal path between node j) and node l).

Figure 7 shows how one embodiment of the invention by its influence in/effect on node l) propagates the error to the signal path between node l) and node m).

Figure 8 shows how one embodiment of the invention by its influence in/effect on node m) detects the propagated error in the primary signal path 210 and instead connects signal from the protection path via the node n); transmitting laser is not switched off.

One arrangement according to one embodiment of the invention includes a set of units as below and should best be implemented as a computer program or in hardware, or as a mixture of them.

With reference to Figure 9, a cross-connector node according to one embodiment of the invention is described. Each input port 910 is equipped with a signal detector 920, intended to detect existence of signal respective loss/lack of signal. Each signal detector is connected to a common control logic 930. The control logic is further connected to a number of timers 941-944, one for each input port. Further, the control logic is connected to an error port memory 950 for storing of identification code for the input ports which have a detected loss of signal and for storing of identification code for the output ports which are connected to these input ports with detected loss of signal. Each input port and each output port is connected to a switch matrix 960 in known way.

At operation of a device according to the invention the following steps are run through:

- signal supervision of incoming signal on input port 1010,
- initiation of a timer at loss of signal 1012,
- storing of identification code for input ports with detected loss of signal 1014,
- storing of identification code for output ports connected to input ports with detected loss of signal 1016,
- supervision of time for loss of signal (control of timer) 1020
- switching, at during specified time remaining loss/ lack of signal, of protection input port to output port, if output port is end port in protected path 1024, 1026.

- switching off, during certain time remaining loss of signal, of output port, that is laser, if output port is part of protected path 1030, 1032,
- re-connection of input port being part of protected path to output port if output port is end port in protected path, at recurrence of signal from input port 1050-1060, and
- switching-on of switched off laser when signal has recurred a certain smallest period of time 1050-1056, 1062, 1064, 1017-1074.

One preferred embodiment of the error detection of the cross-connector node is shown by the following algorithm:

```
Array:          TXArray
Time-out-period: TIME

Rx-port:        Rxn
Rx-port:        Protection-Rx

1.  "Signal Detect" (SD) for RXn high
2.  Wait for SD low
3.  Detection of loss of signal (SD low in Rxn-port)
4.  Initiate timer
5.  Tx-ports connected to Rxn-port with detected loss
    of signal -> TXArray
6.  If loss of signal unchanged during a certain
    period of time TIME:

    a.  For each Tx-port in TXArray:
        i.  if Tx-port is end port in protected
            path (that is, primary path)
            1. connect protection Rx-port to Tx-
            port
        ii. otherwise if Tx-port is part of
            protected path
```

1. switch off Tx-port (laser) so that the error propagates

7.

a. Wait for SD high
b. SD high detected on Tx-port
c. Initiate timer
d. If SD high unchanged during a certain period of time TIME:
i. for each Tx-port in TXArray:
1. if each Tx-port is end port in protection path:
a. connect Rxn-port to Tx-port
2. otherwise if Tx-port is part of protection path:
a. switch on Tx-port (laser) so that the signal propagates

8. Return to (1)

PATENT CLAIMS

1. Method for error detection and signal path protection in optical communication networks, c h a r a c t e r i z e d in the following steps:
   - supervision of incoming signal on input port (1010),
   - switching off/disconnection of output port at loss of signal in the case output port is part of protected path (1030, 1032), and
   - connection of protection input port to output port at loss of signal in the case output port is end port in protected path (1024, 1026).

2. Method as claimed in patent claim 1, c h a r a c t e r i z e d in that it also includes the steps:
   - reconnection/re-switching of input port being part of primary path to output port in the case said output port is end port in protected path and the signal at said input port has recurred (1058, 1060).
   - switching on of switched off laser in the case the signal at the input port being part of primary signal path has recurred (1062, 1064).

3. Device at cross connector node in an optical communication network including input ports, output ports and a switch matrix, c h a r a c t e r i z e d in signal detectors (920) at each input port (910) which detects loss of signal, if any, and communicates this via one or more connections to a control logic (930), said control logic being connected to output ports (970) and switch matrix (960).

4. Device as claimed in patent claim 3, further

c h a r a c t e r i z e d in a set of timers connected with the control logic and intended to be possible to start at loss of signal and signal to the control logic when this has been the state for a certain period of time.

5. Device as claimed in patent claim 4, c h a r a c t e r i z e d in an error port memory (950) connected to the control logic (930) and intended to store information about which output ports that are connected to input ports with detected loss of signal.

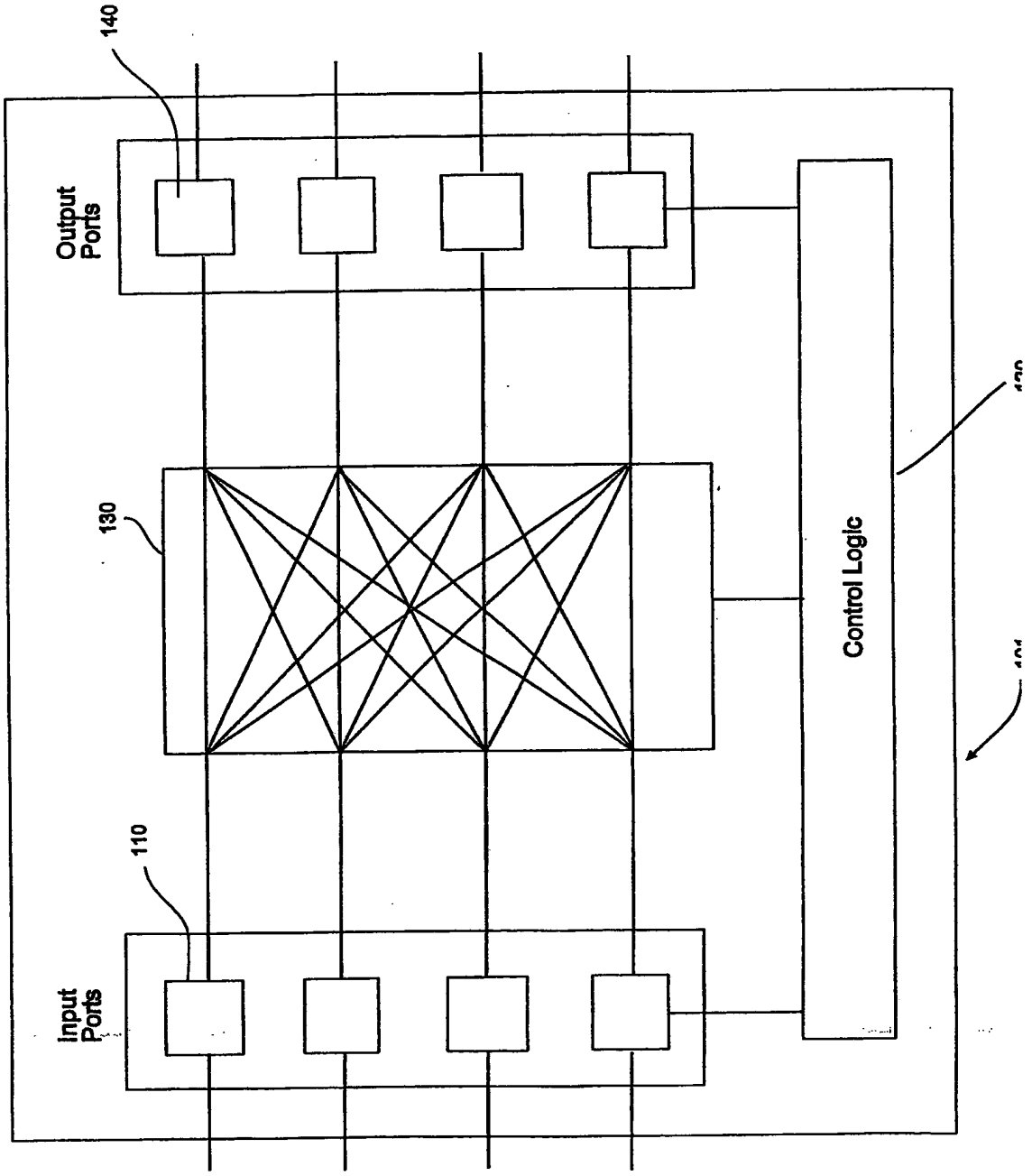


Figure 1

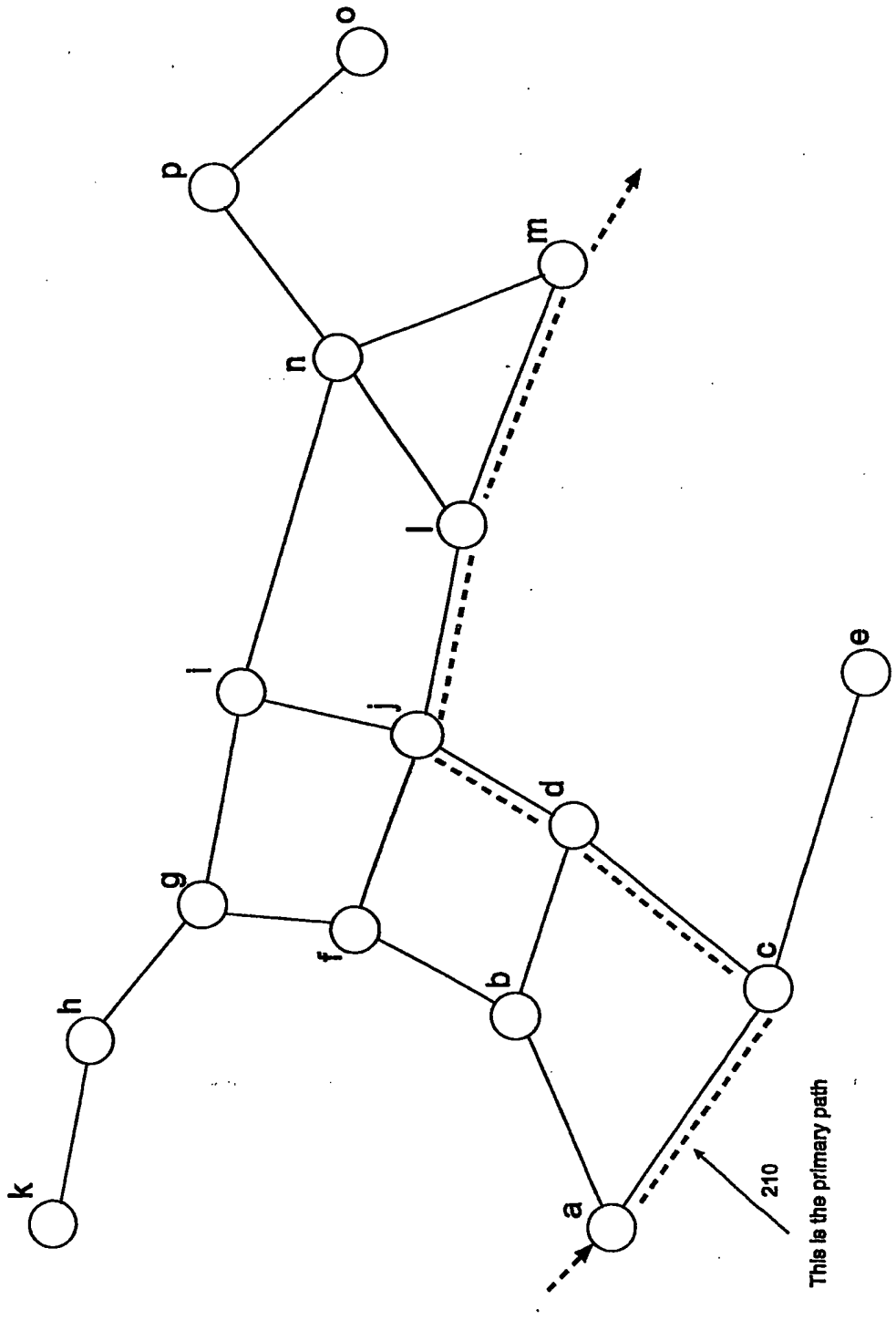


Figure 2

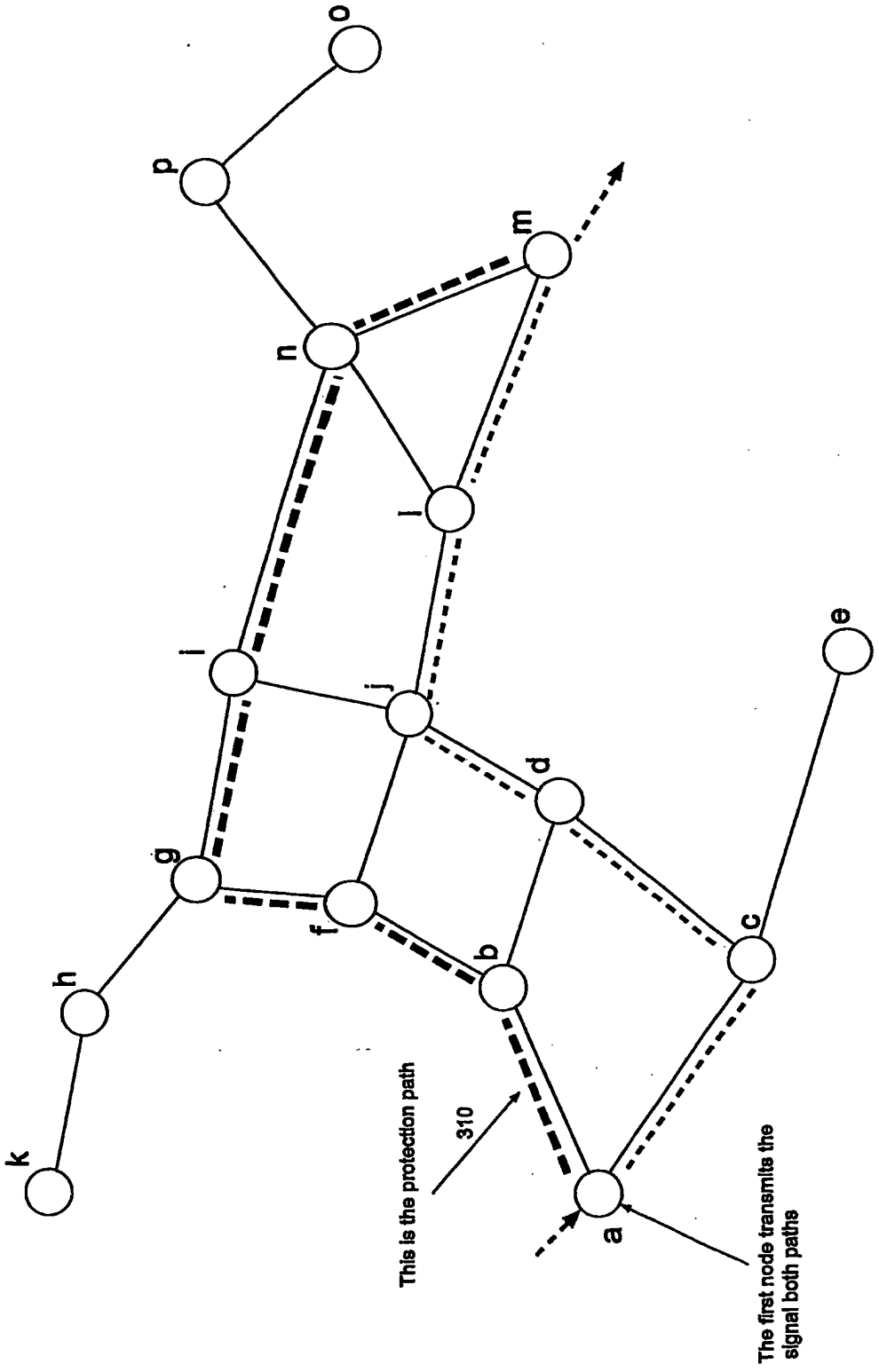
o
p
m
n
l
i
j
e
d
g
f
c
b
h
k
a
This is the protection path
310
The first node transmits the signal both paths

Figure 3

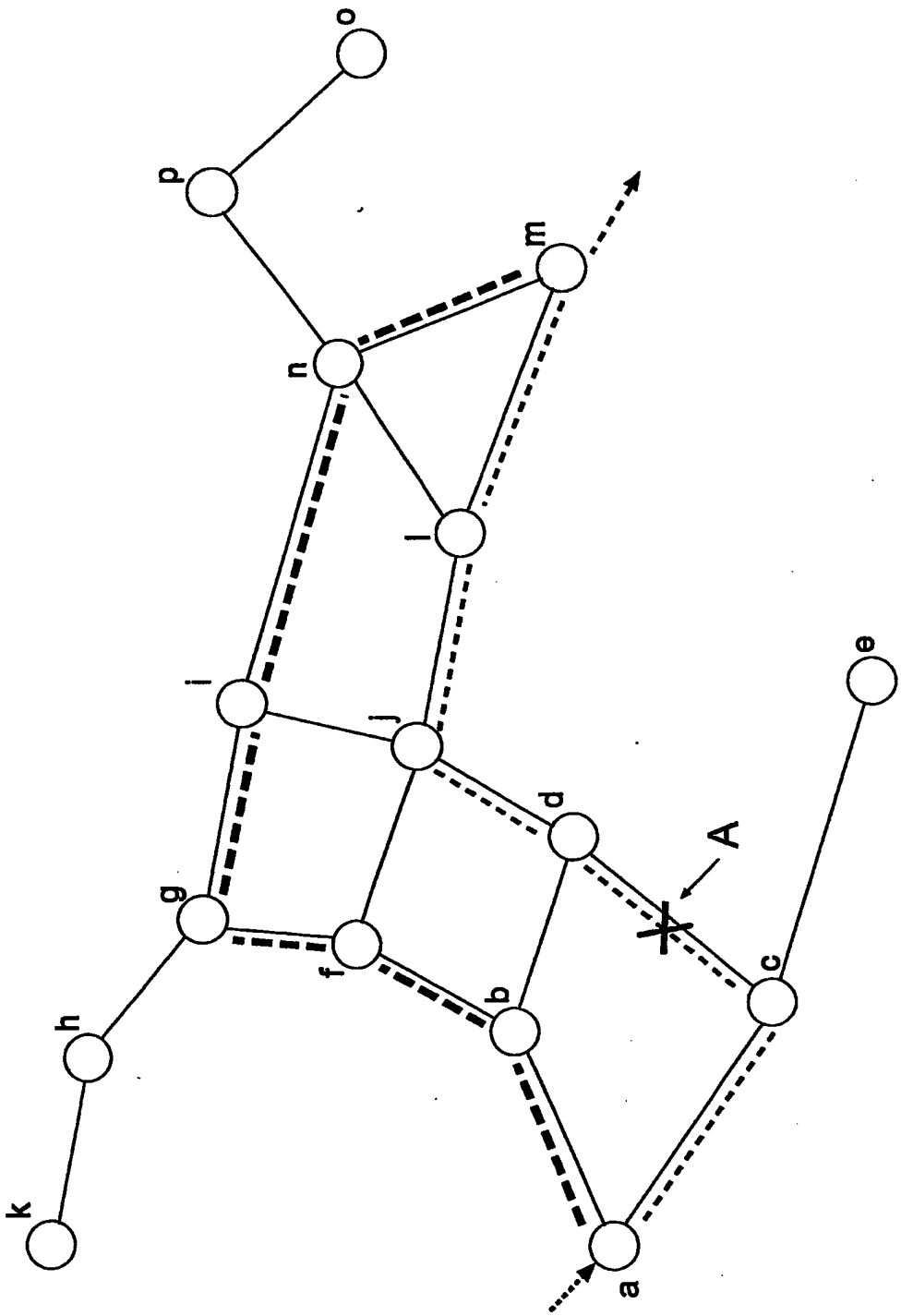


Figure 4

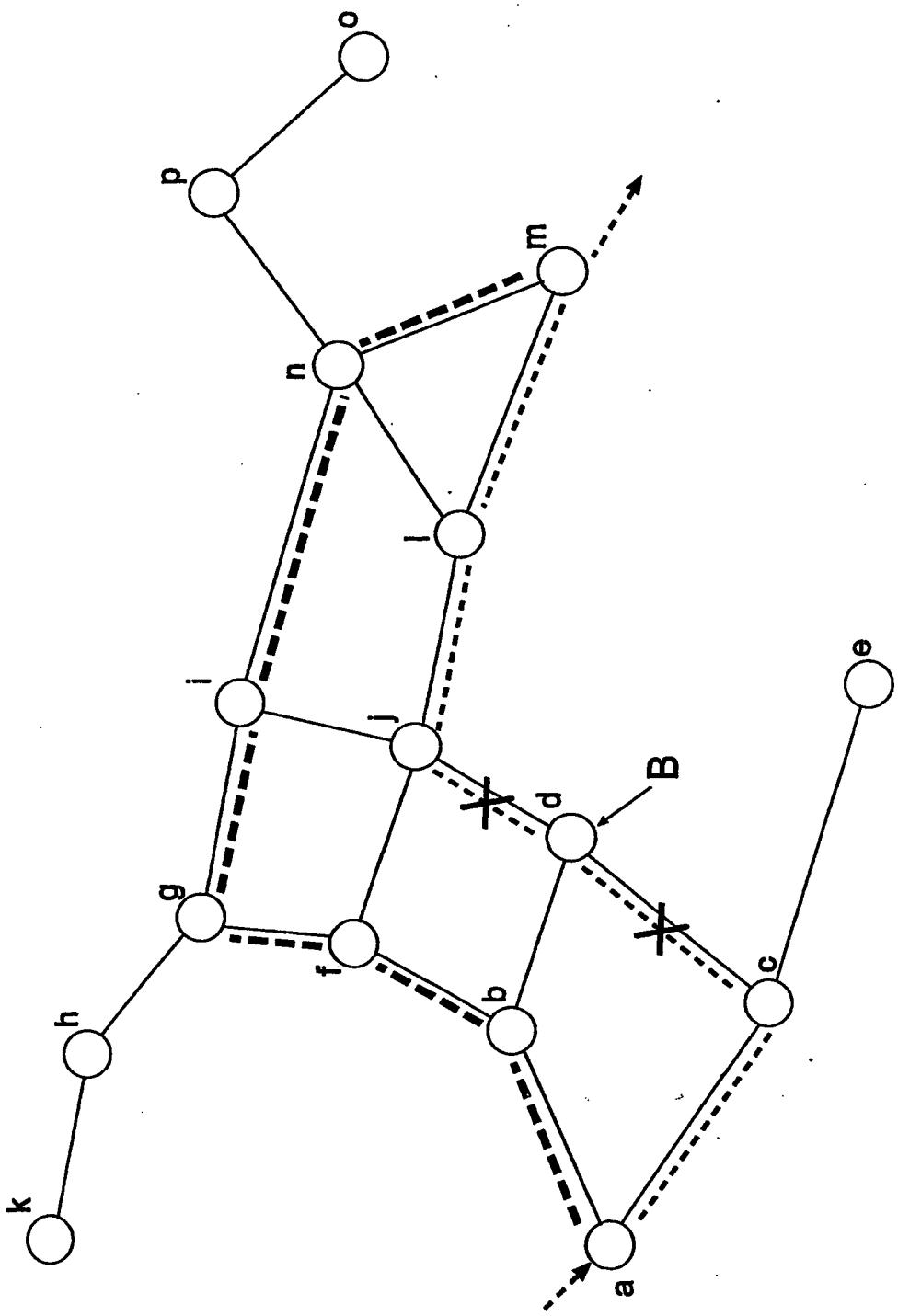


Figure 5

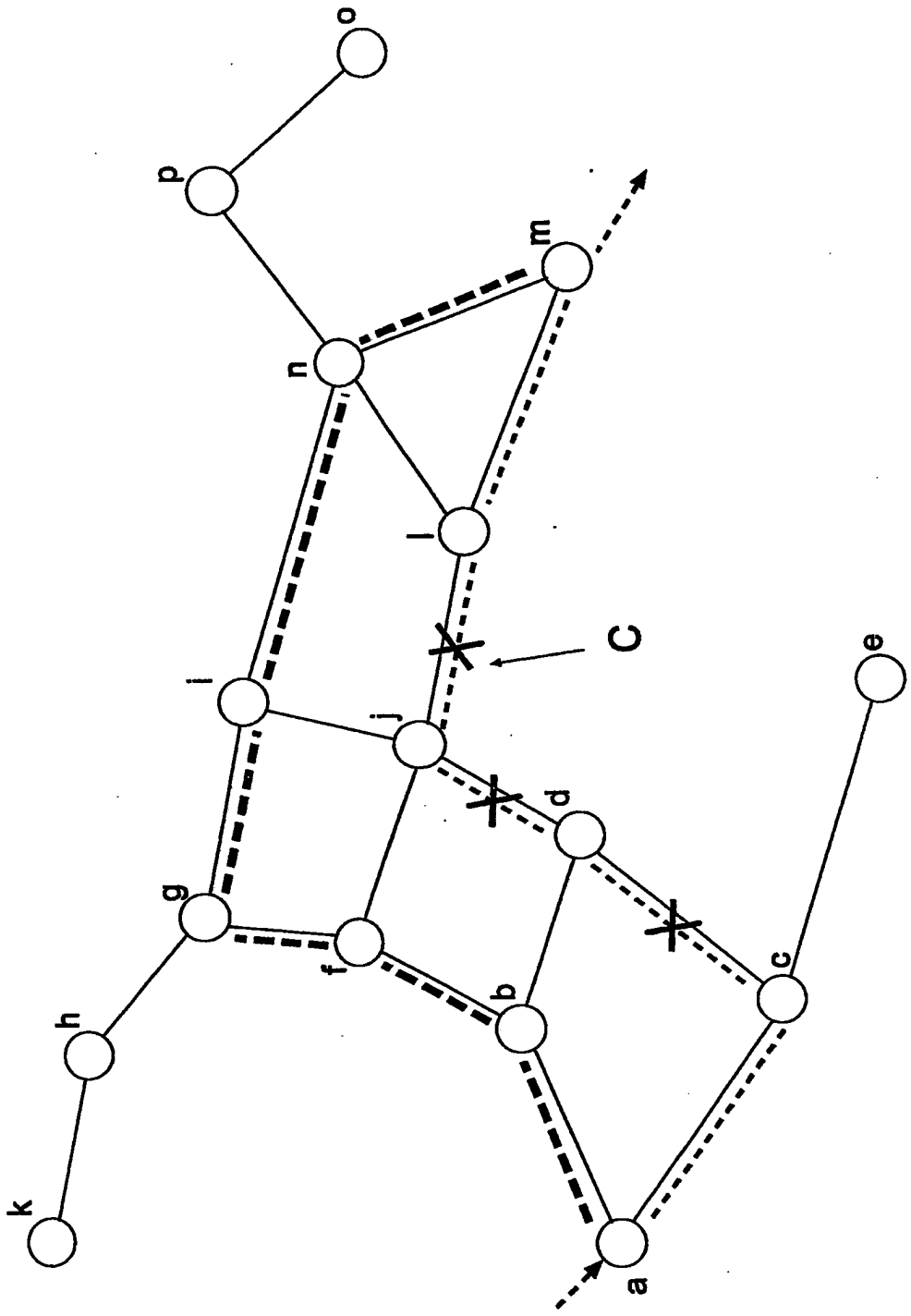


Figure 6

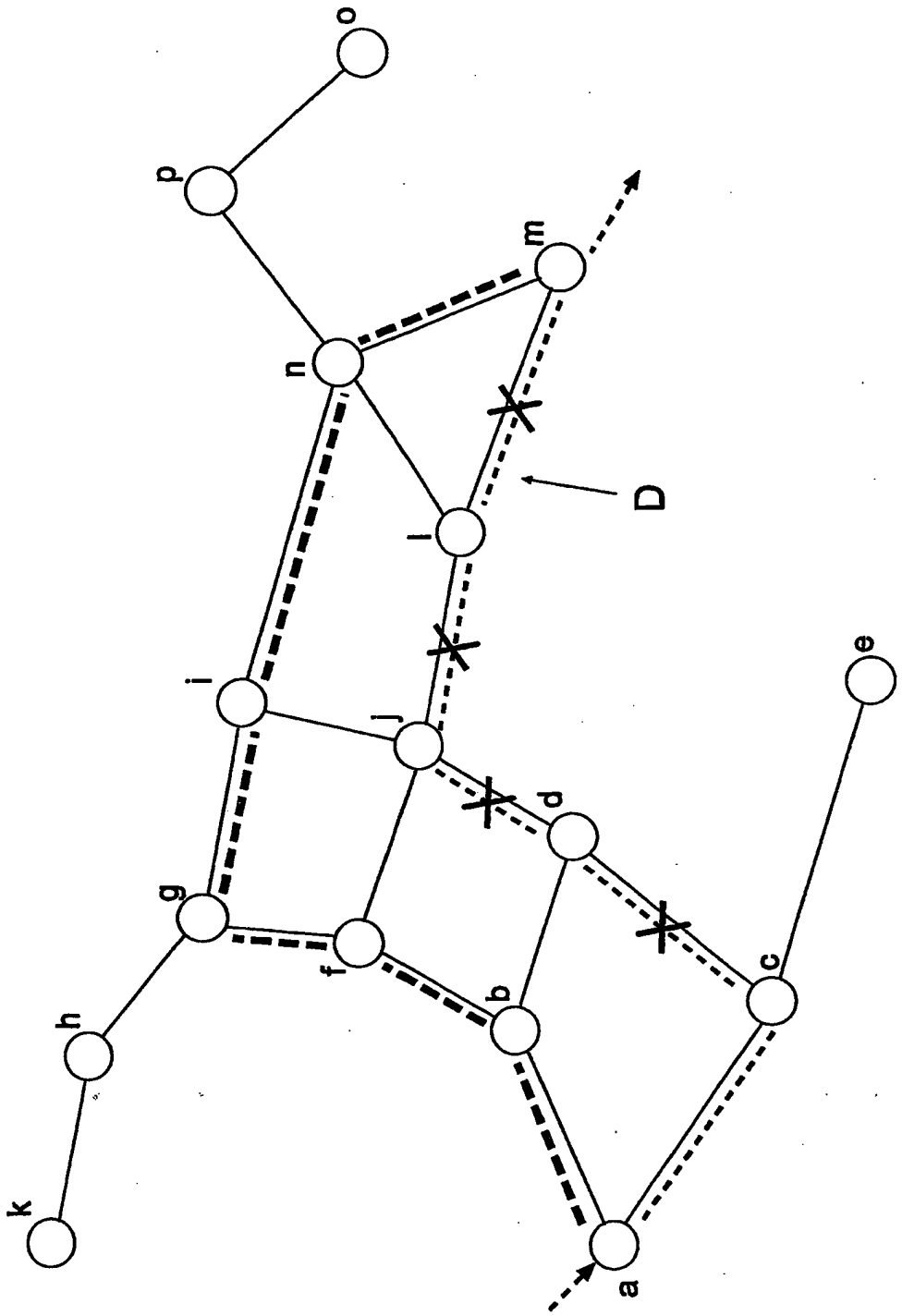


Figure 7

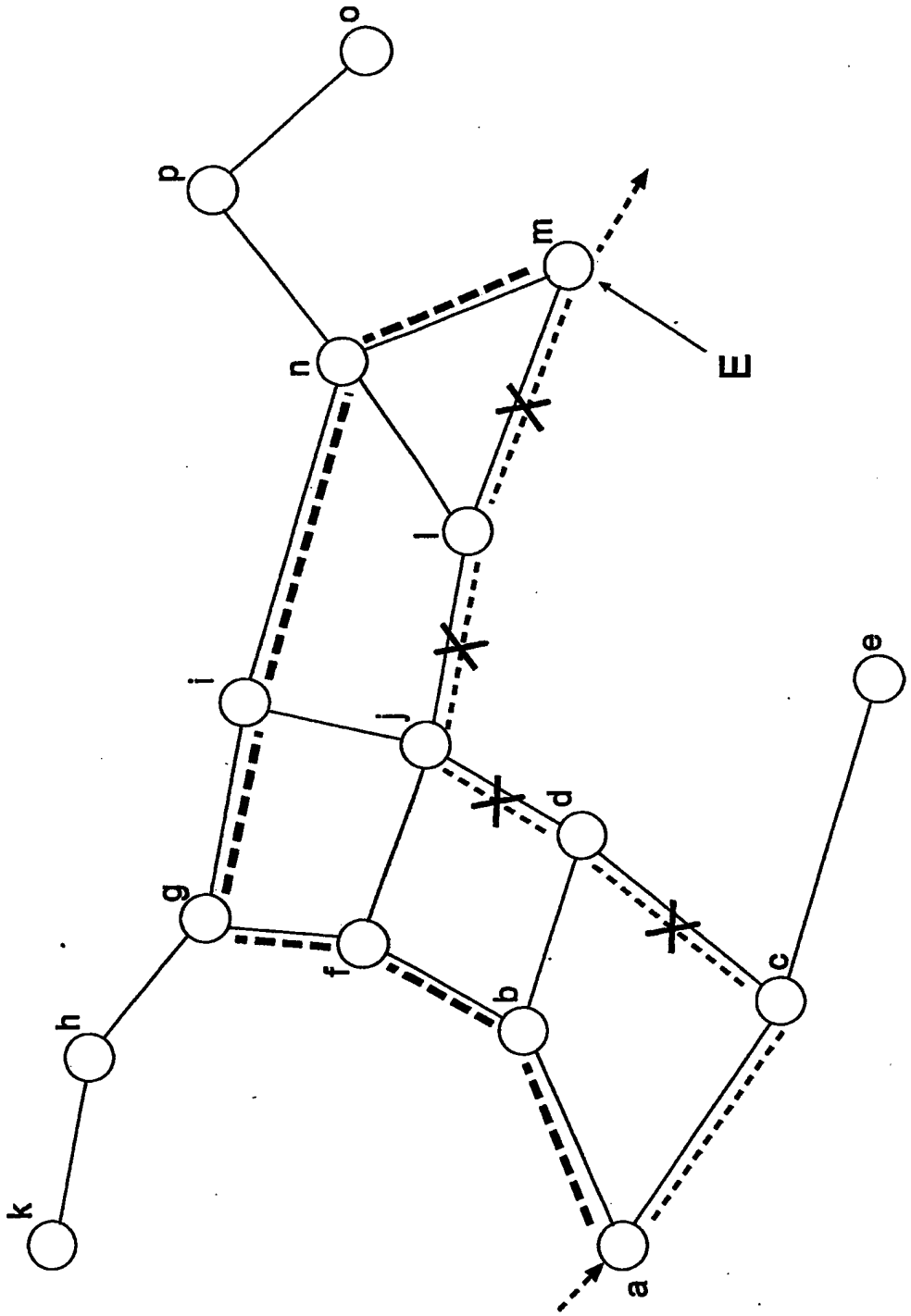


Figure 8

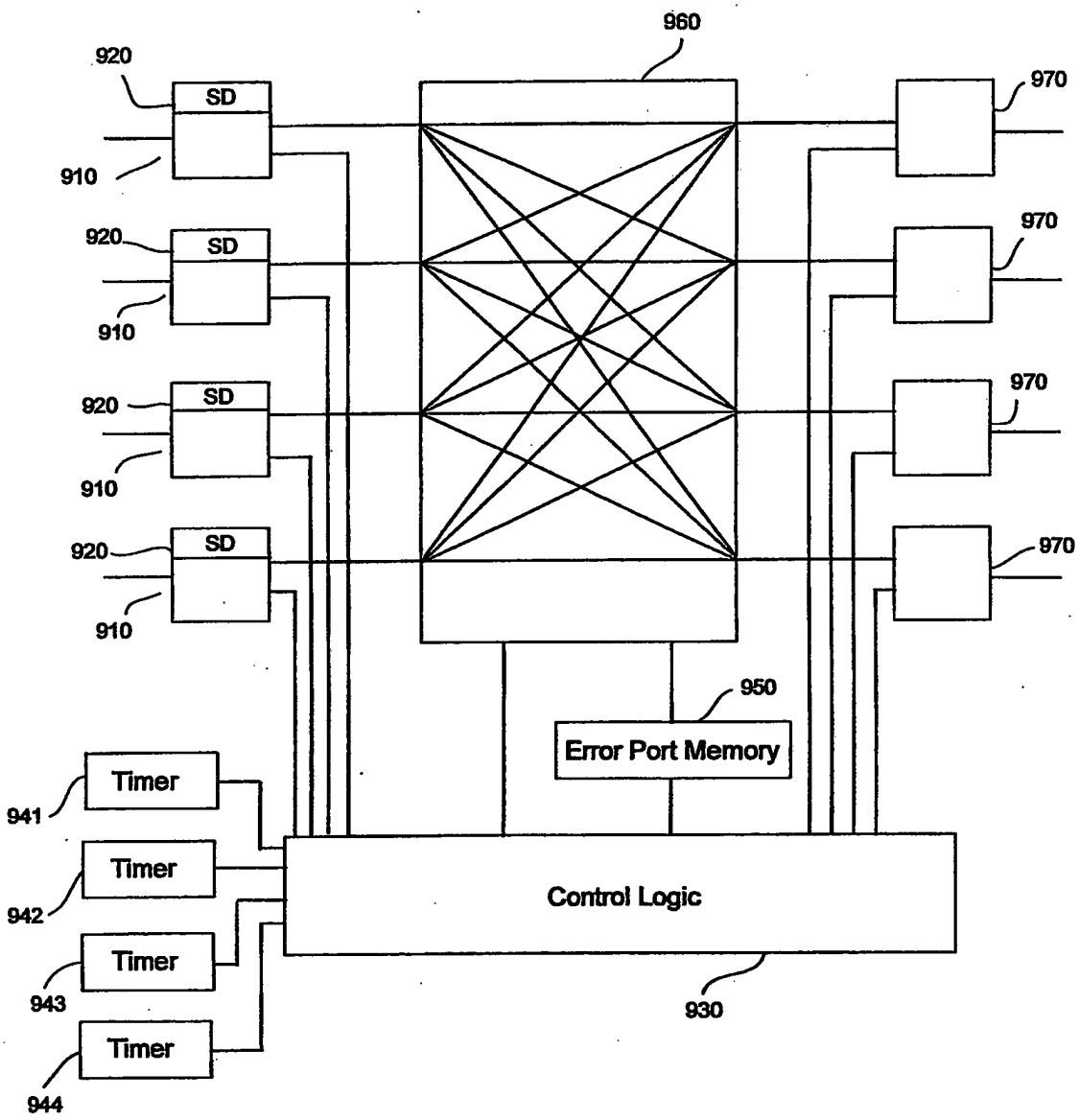
960
920
SD
910
970
Error Port Memory
950
Timer
941
942
943
944
Control Logic
930

Figure 9

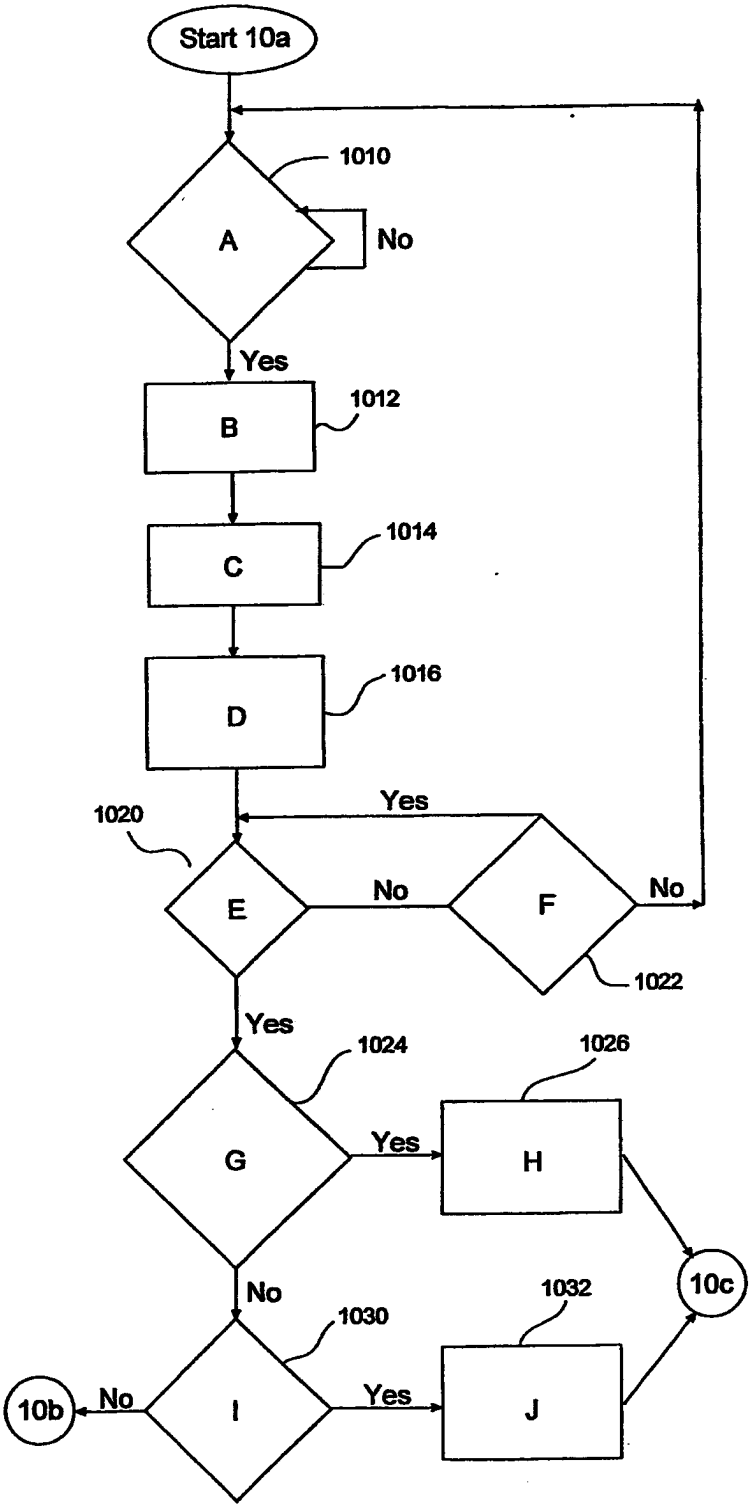
Start 10a
1010
A
No
Yes
1012
B
1014
C
1016
D
Yes
1020
E
No
F
No
1022
Yes
1024
1026
G
Yes
H
No
1032
10c
1030
10b
No
I
Yes
J

Figure 10a

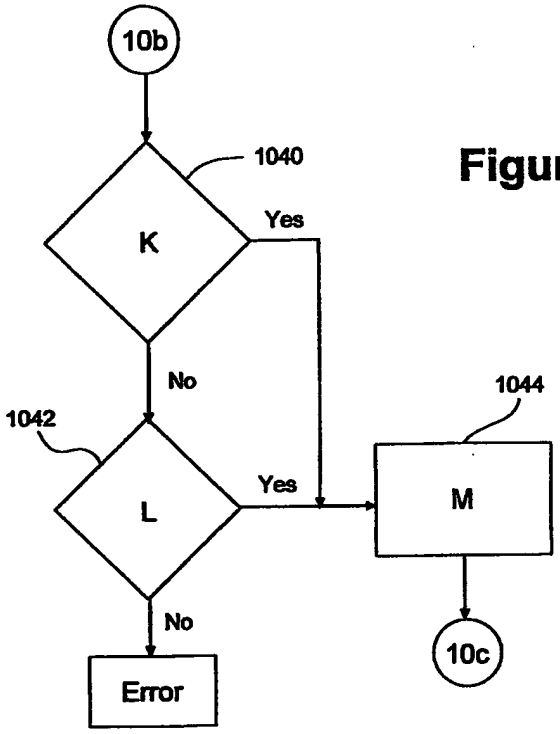


Figure 10b

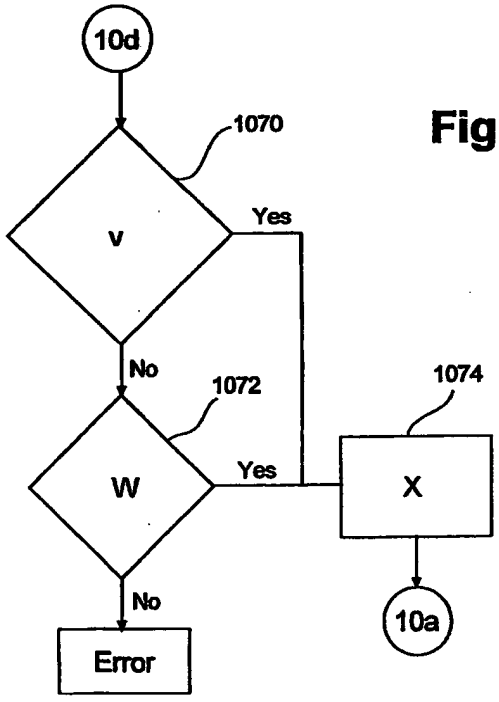


Figure 10d

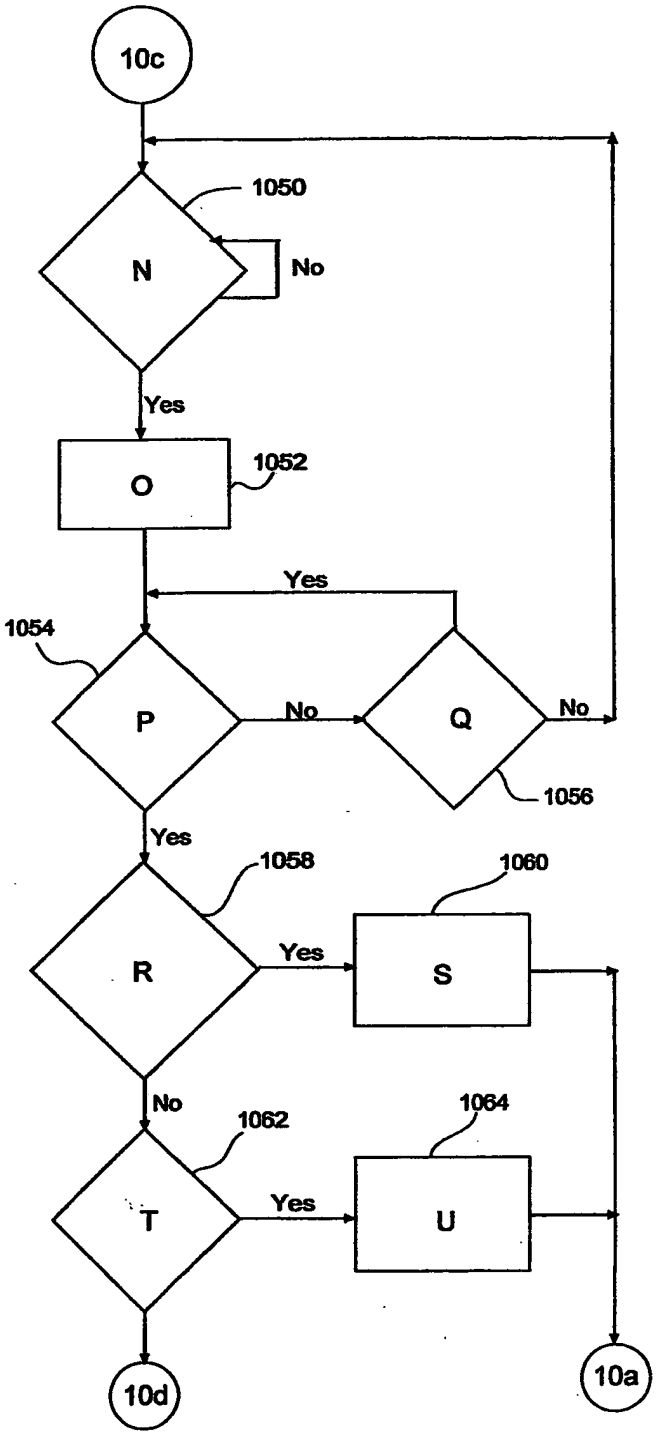
10c
1050
N
No
Yes
O
1052
Yes
1054
P
No
Q
No
1056
Yes
1058
1060
R
Yes
S
No
1062
1064
T
Yes
U
10d
10a

Figure 10c

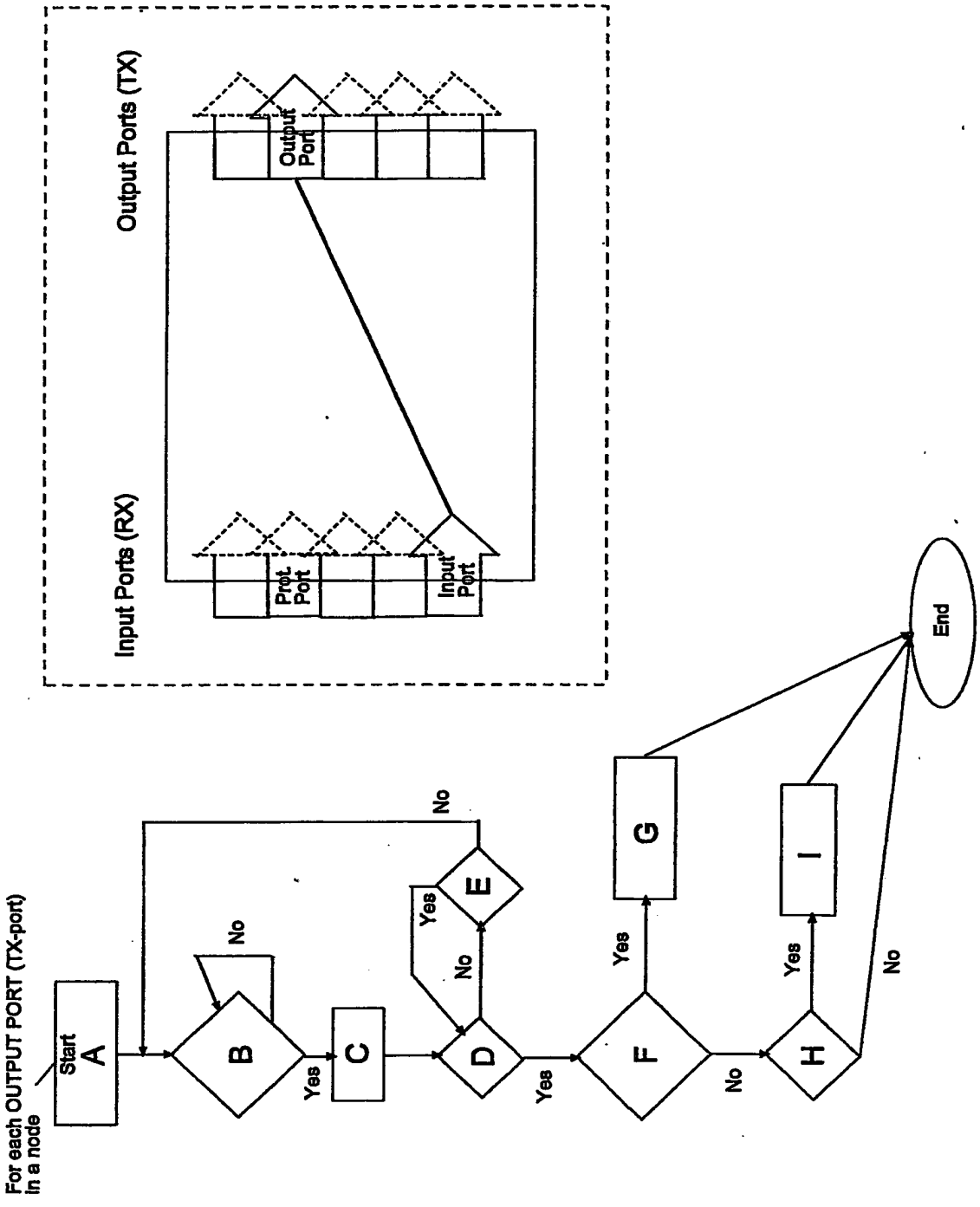
Output Ports (TX)
Output Port
Input Ports (RX)
Prot. Port
Input Port
For each OUTPUT PORT (TX-port) in a node
Start
A
B
No
Yes
C
D
No
E
No
Yes
Yes
F
G
Yes
H
I
Yes
No
No
End

Figure 11

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/00230

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04B 10/00, H04B 10/08, H04Q 11/00
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04B, H04Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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| Y | -- | 2 |
| Y | DE 4421642 A1 (SIEMENS AG), 4 January 1996 (04.01.96), claim 1 | 2 |
| | -- | |
| X | EP 0973354 A2 (LUCENT TECHNOLOGIES INC.), 19 January 2000 (19.01.00), column 5, line 58 - column 6, line 22; column 12, line 25 - line 29, figure 2 | 3-5 |
| | -- | |

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 6 May 2003 | 16 -05- 2003 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br>GÖRAN MAGNUSSON/BS<br>Telephone No. +46 8 782 25 00 |

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 03/00230

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | EP 0957646 A1 (ALCATEL), 17 November 1999 (17.11.99), abstract<br>--- | 1-5 |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

29/03/03

International application No.
PCT/SE 03/00230

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| EP 0973354 A2 | 19/01/00 | AU 4011499 A | 10/02/00 |
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| | | JP 2000078082 A | 14/03/00 |
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| | | SE 0579040 T3 | |
| | | ES 2141122 T | 16/03/00 |
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